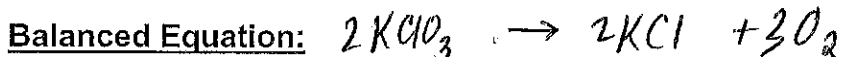


## Mixed Stoichiometry Practice

Name \_\_\_\_\_

Write and/or balance the following equations (remember the diatomic elements and to criss-cross charges for ionic compounds!!!) Use the mole ratios from the balanced equations to solve the following stoichiometry problems. Use units and labels in all conversions, and round your answer to sig figs.

1. Potassium chlorate decomposes into potassium chloride and oxygen gas.



2. How many moles of oxygen are produced when 3.0 moles of potassium chlorate decompose completely?

$$3.0 \text{ mol KClO}_3 \left( \frac{3 \text{ mol O}_2}{2 \text{ mol KClO}_3} \right) = 4.5 \text{ mol O}_2$$

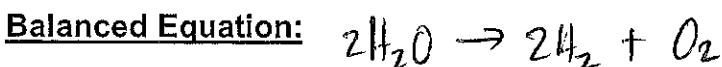
3. Butane ( $\text{C}_4\text{H}_{10}$ ) undergoes combustion.



4. How many grams of  $\text{CO}_2$  are produced when 88 g of  $\text{O}_2$  are reacted with an excess of butane?

$$88 \text{ g O}_2 \left( \frac{1 \text{ mol O}_2}{32 \text{ g O}_2} \right) \left( \frac{8 \text{ mol CO}_2}{13 \text{ mol O}_2} \right) \left( \frac{44 \text{ g CO}_2}{1 \text{ mol CO}_2} \right) = 74 \text{ g CO}_2$$

5. Water decomposes into hydrogen gas and oxygen gas by electrolysis.



6. How many grams of hydrogen will be produced when 6.0 moles of oxygen are produced?

$$6.0 \text{ moles O}_2 \left( \frac{2 \text{ mol H}_2}{1 \text{ mol O}_2} \right) \left( \frac{2 \text{ g H}_2}{1 \text{ mol H}_2} \right) = 24 \text{ g H}_2$$

7. How many grams of water are required to produce 1.5L of hydrogen at STP?

$$1.5 \text{ L H}_2 \left( \frac{1 \text{ mol H}_2}{22.4 \text{ L}} \right) \left( \frac{2 \text{ mol H}_2\text{O}}{2 \text{ mol H}_2} \right) \left( \frac{18 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} \right) = 1.2 \text{ g H}_2\text{O}$$

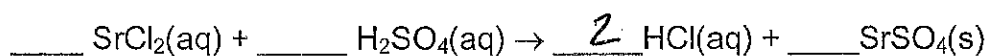
8. Cobalt(II) chloride reacts with fluorine in a single replacement reaction to produce cobalt(II) fluoride and chlorine gas.

**Balanced Equation:**  $\text{CoCl}_2 + \text{F}_2 \rightarrow \text{CoF}_2 + \text{Cl}_2$

9. How many grams of fluorine are required to produce 290.8 g of cobalt(II) fluoride?

$$290.8 \text{ g CoF}_2 \left( \frac{1 \text{ mol CoF}_2}{96.9 \text{ g CoF}_2} \right) \left( \frac{1 \text{ mol F}_2}{1 \text{ mol CoF}_2} \right) \left( \frac{38 \text{ g F}_2}{1 \text{ mol F}_2} \right) = 114.0 \text{ g F}_2$$

10. Balance the following equation.



11. What is the mass of strontium chloride that reacts with 300.0 g of sulfuric acid?

$$300.0 \text{ g H}_2\text{SO}_4 \left( \frac{1 \text{ mol H}_2\text{SO}_4}{98.08 \text{ g H}_2\text{SO}_4} \right) \left( \frac{1 \text{ mol SrCl}_2}{1 \text{ mol H}_2\text{SO}_4} \right) \left( \frac{158.6 \text{ g SrCl}_2}{1 \text{ mol SrCl}_2} \right) = 440.1 \text{ g SrCl}_2$$

12. Solid iron(III) oxide reacts with hydrogen gas to form iron and water.

**Balanced Equation:**  $\text{Fe}_2\text{O}_3 + 3 \text{H}_2 \rightarrow 2 \text{Fe} + 3 \text{H}_2\text{O}$

13. How many grams of iron are produced when 450 grams of iron(III) oxide are reacted?

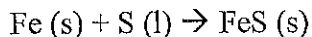
$$450 \text{ g Fe}_2\text{O}_3 \left( \frac{1 \text{ mol Fe}_2\text{O}_3}{159.6 \text{ g Fe}_2\text{O}_3} \right) \left( \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} \right) \left( \frac{55.8 \text{ g Fe}}{1 \text{ mole Fe}} \right) = 310 \text{ g Fe}$$

14. How many grams of water will be produced when 3.2L of hydrogen gas react completely with iron(III) oxide at STP?

$$3.2 \text{ L H}_2 \left( \frac{1 \text{ mol H}_2}{22.4 \text{ L H}_2} \right) \left( \frac{3 \text{ mol H}_2\text{O}}{3 \text{ mol H}_2} \right) \left( \frac{18 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} \right) = 2.6 \text{ g H}_2\text{O}$$

# LIMITING REAGENT Practice Problems

1. At high temperatures, sulfur combines with iron to form the brown-black iron (II) sulfide:



*Ratio from Equation* *Ratio from Given*  
 $1 \text{ mol Fe} : 1 \text{ mol S}$   $1 \text{ mol Fe} : 1.97 \text{ mol S}$

In one experiment, 7.62 g of Fe are allowed to react with 8.67 g of S.

- a. What is the limiting reagent, and what is the reactant in excess?

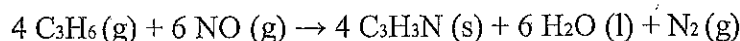
$$7.62 \text{ g Fe} \left( \frac{1 \text{ mol}}{55.8 \text{ g}} \right) = 0.137 \text{ mol Fe} \quad 8.67 \text{ g S} \left( \frac{1 \text{ mol}}{32.0 \text{ g}} \right) = 0.270 \text{ mol S}$$

- b. Calculate the mass of FeS formed.

$$7.62 \text{ g Fe} \left( \frac{1 \text{ mol Fe}}{55.8 \text{ g}} \right) \left( \frac{1 \text{ mol FeS}}{1 \text{ mol Fe}} \right) \left( \frac{87.9 \text{ g}}{1 \text{ mol FeS}} \right) = 12.0 \text{ g FeS}$$

*Sulfur is in excess.*

2. Acrylonitrile,  $\text{C}_3\text{H}_3\text{N}$ , is the starting material for the production of a kind of synthetic fiber (acrylics) and can be made from propylene,  $\text{C}_3\text{H}_6$ , by reaction with nitric oxide,  $\text{NO}$ , as follows:



What mass of  $\text{C}_3\text{H}_3\text{N}$  can be made when 21.6 g of  $\text{C}_3\text{H}_6$  react with 21.6 g of nitric oxide?

$$21.6 \text{ g C}_3\text{H}_6 \left( \frac{1 \text{ mol}}{42.0 \text{ g}} \right) = 0.514 \text{ mol C}_3\text{H}_6$$

*Ratio from Equation*  
 $4 \text{ C}_3\text{H}_6 : 6 \text{ NO}$   
 $2 \text{ C}_3\text{H}_6 : 3 \text{ NO}$

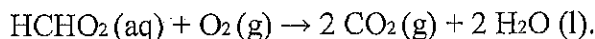
*NO is limiting*

$$21.6 \text{ g NO} \left( \frac{1 \text{ mol}}{30 \text{ g}} \right) = 0.720 \text{ mol NO}$$

*Ratio from given*  
 $1 \text{ mol C}_3\text{H}_6 : 1.4 \text{ mol NO}$

$$21.6 \text{ g NO} \left( \frac{1 \text{ mol NO}}{30 \text{ g NO}} \right) \left( \frac{4 \text{ mol C}_3\text{H}_3\text{N}}{6 \text{ mol NO}} \right) \left( \frac{53 \text{ g}}{1 \text{ mol C}_3\text{H}_3\text{N}} \right) = 25.4 \text{ g C}_3\text{H}_3\text{N}$$

3. Formic acid,  $\text{HCHO}_2$ , burns in oxygen to form carbon dioxide and water as follows:



If a 3.15-g sample of formic acid was burned in 2.0 L of oxygen, what volume of carbon dioxide would be produced? (Assume the reaction occurs at standard temperature and pressure, STP.)

$$3.15 \text{ g HCHO}_2 \left( \frac{1 \text{ mol}}{46 \text{ g HCHO}_2} \right) = 0.685 \text{ mol HCHO}_2$$

*from equation*  
 $1 \text{ mol HCHO}_2 : 1 \text{ mol O}_2$

*O}\_2 \text{ is limiting}*

$$2.0 \text{ L O}_2 \left( \frac{1 \text{ mol}}{22.4 \text{ L}} \right) = 0.0893 \text{ mol O}_2$$

*from given*  
 $7.67 \text{ mol HCHO}_2 : 1 \text{ mol O}_2$

$$2.0 \text{ L O}_2 \left( \frac{1 \text{ mol O}_2}{22.4 \text{ L}} \right) \left( \frac{2 \text{ mol CO}_2}{1 \text{ mol O}_2} \right) \left( \frac{22.4 \text{ L}}{1 \text{ mol CO}_2} \right) = 4.0 \text{ L CO}_2$$

4. Zinc metal reacts with hydrochloric acid to produce zinc chloride and hydrogen gas.

- a. Balance the following reaction:  $\text{Zn (s)} + 2\text{HCl (aq)} \rightarrow \text{ZnCl}_2 \text{ (aq)} + \text{H}_2 \text{ (g)}$

- b. A 3.50-g sample of zinc metal is allowed to react with 2.50 g of hydrochloric acid.

Complete the following table:

Reactants/products	Zn (grams)	HCl (grams)	ZnCl <sub>2</sub> (grams)	H <sub>2</sub> (grams)
Before reaction	3.50	2.50	0	0
After reaction	1.26 g Not All Used	0	4.67	0.14

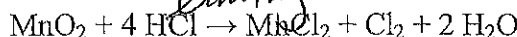
*MUST BE IN EXCESS*

$$2.50 \text{ g HCl} \left( \frac{1 \text{ mol HCl}}{36.5 \text{ g}} \right) \left( \frac{1 \text{ mol ZnCl}_2}{2 \text{ mol HCl}} \right) \left( \frac{136 \text{ g}}{1 \text{ mol ZnCl}_2} \right) = 4.67 \text{ g ZnCl}_2$$

$$3.50 \text{ g Zn} \left( \frac{1 \text{ mol Zn}}{65.4 \text{ g}} \right) \left( \frac{1 \text{ mol H}_2}{1 \text{ mol Zn}} \right) \left( \frac{2 \text{ g}}{1 \text{ mol H}_2} \right) = 0.14 \text{ g H}_2$$

From given 1 mol  $\text{MnO}_2$  : 3.25 mol  $\text{HCl}$

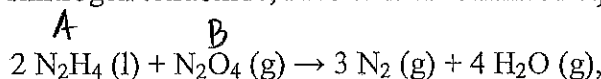
5. Consider the reaction:



If 0.45 mols of  $\text{MnO}_2$  can react with 48.2 g of  $\text{HCl}$ , how many grams of  $\text{Cl}_2$  could be produced?

$$48.2 \text{ g HCl} \left( \frac{1 \text{ mol}}{36.5 \text{ g}} \right) = \frac{1.3 \text{ mol HCl}}{0.45} \quad \text{0.45 mol MnO}_2 \quad 48.2 \text{ g HCl} \left( \frac{1 \text{ mol HCl}}{36.5 \text{ g}} \right) \left( \frac{1 \text{ mol Cl}_2}{4 \text{ mol HCl}} \right) \left( \frac{71 \text{ g}}{1 \text{ mol Cl}_2} \right) = \boxed{23.4 \text{ g Cl}_2}$$

6. One of the components of the fuel mixture on the Apollo lunar module involved a reaction with hydrazine,  $\text{N}_2\text{H}_4$ , and dinitrogen tetroxide,  $\text{N}_2\text{O}_4$ . If the balanced equation for this reaction is



What volume of  $\text{N}_2$  gas (measured at STP) would result from the reaction of 1500 kg of hydrazine and 1000 kg of  $\text{N}_2\text{O}_4$ ?

$$1500 \text{ kg A} \left( \frac{1000 \text{ g}}{1 \text{ kg}} \right) \left( \frac{1 \text{ mol A}}{32 \text{ g}} \right) = 47,000 \text{ mol A} \quad 1000 \text{ kg B} \left( \frac{1000 \text{ g}}{1 \text{ kg}} \right) \left( \frac{1 \text{ mol B}}{92 \text{ g}} \right) = 10,000 \text{ mol B}$$

7. Chlorine gas reacts with silica,  $\text{SiO}_2$ , and carbon to give silicon tetrachloride and carbon monoxide.

a. Balance the following equation:  $\text{Cl}_2 (\text{g}) + \text{SiO}_2 (\text{s}) + \text{C} (\text{s}) \rightarrow \text{SiCl}_4 (\text{l}) + \text{CO} (\text{g})$

b. How much  $\text{CO}$  gas can be produced from 15.0 g of silica?

From given limiting Reactant Excess Reactant

$$\frac{47,000 \text{ mol A}}{10,000 \text{ mol B}} = \frac{1 \text{ mol B}}{4.7 \text{ mol A}}$$

From Equation 1 mol B : 2 mol A

$$1000 \text{ kg B} \left( \frac{1000 \text{ g}}{1 \text{ kg}} \right) \left( \frac{1 \text{ mol B}}{92 \text{ g}} \right) \left( \frac{3 \text{ mol N}_2}{1 \text{ mol B}} \right) \left( \frac{22.4 \text{ L}}{1 \text{ mol N}_2} \right) = \boxed{7 \times 10^5 \text{ L N}_2}$$

\* No mention of STP  
solve in grams

$$15.0 \text{ g SiO}_2 \left( \frac{1 \text{ mol SiO}_2}{60.1 \text{ g}} \right) \left( \frac{2 \text{ mol CO}}{1 \text{ mol SiO}_2} \right) \left( \frac{28 \text{ g CO}}{1 \text{ mol CO}} \right) = \boxed{14.0 \text{ g CO}}$$